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Land Manager Perspectives on Conflict Mitigation Strategies for Urban Flying-Fox Camps

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Abstract: Over the last 20 years, there has been a notable increase in the presence of flying-foxes (*Pteropodidae*) in urban areas in Australia. Flying-foxes congregate during the day in camps which at times may contain many thousands of individuals. The associated noise, smell, mess and concerns about disease transmission can result in significant conflict with local communities. Managers of flying-fox camps use a range of management approaches to mitigate tensions, but the success or otherwise of these has been largely undocumented. Land managers were surveyed to determine the relative cost and perceived effectiveness of mitigation strategies using semi-structured interviews and an online questionnaire. We found that five actions were commonly used to manage flying-foxes: (1) stakeholder education, (2) the creation of buffers between camps and adjacent residents via vegetation removal or (3) the creation of buffers via deterrents, (4) dispersal of flying-foxes via disturbance, and (5) dispersal of flying-foxes via vegetation removal. Perceptions of effectiveness varied considerably among managers. Overall, the creation of buffers via vegetation removal was considered the most effective action, and stakeholder education was perceived to be the least effective. Dispersal via disturbance was also considered effective at reducing complaints and improving amenity, but not particularly effective overall likely due to the often short-term relief provided to residents before camps were recolonised. It was evident that the actions taken by managers and their perceived effectiveness were influenced by the attitudes of the community. This highlights the importance of considering the human dimensions of human-wildlife conflict in mitigation strategies.

Keywords: wildlife management; human-wildlife conflict; *Pteropus*; human dimensions; dispersal; buffers; Chiroptera; urban ecology

1. Introduction

Human-wildlife conflict is a significant issue in many parts of the world [1]. Major drivers of conflict are the encroachment of expanding human populations into wildlife habitat, or wildlife colonising or utilising human-dominated areas [2]. Although direct damage caused by wildlife is often implicated as the main cause of conflict, in reality, conflict can arise whenever the presence of wildlife threatens, or is perceived to threaten human interests, be they aesthetic, social or economic [3,4].

While much of the human-wildlife conflict literature focuses on large vertebrates [2], other species such as bats can cause conflict. The Pteropididae family comprises over 170 species of flying-foxes and is distributed widely in tropical and subtropical countries [5]. Flying-foxes feed primarily on flowers and fruit, and are vital pollinators and seed dispersers for a large range of food, timber and forest

plant species [6,7]. However, their foraging activities can also damage a wide variety of fruit crops, often causing considerable economic losses in many countries [8]. Conflict between fruit growers and flying-foxes has long been an issue in Australia; however, the focus of this study is conflict caused by the presence of flying-foxes in urban areas.

There are four species of flying-foxes on the Australian mainland: the Black flying-fox (*Pteropus alecto*), the Grey-headed flying-fox (*P. poliocephalus*), the Little red flying-fox (*P. scapulatus*) and the Spectacled flying-fox (*P. conspicillatus*). At night individuals may travel up to 50 km to forage on fruit and nectar, and by day they congregate in roosts, also commonly called camps. The number of flying-foxes present at a camp is highly dynamic as their movement patterns are largely driven by irregular and ephemeral resource availability [9,10]. Camps may have few or no flying-foxes at times, but at other times be occupied by tens or even hundreds of thousands of individuals [11]. As well as providing a resting site, camps are where most social interaction and reproduction occur, including conception, birth and lactation [12].

In the last 20 years there has been a notable increase in the presence of flying-foxes in existing cities and towns [13–15]. Habitat loss and changes to local climates have been suggested as likely causes [16,17], as has the growing availability of food resources from private and public gardens and street plantings [18,19]. Urban development is also encroaching on roosting habitat in some areas, and the increasing interaction between flying-foxes and local communities can result in significant tension. Conflict can occur when camps are located in close proximity to residents, businesses, public spaces, and government buildings such as schools. The noise, smell and mess associated with flying-fox camps can reduce the amenity of private and public spaces, causing significant concern for some people; others complain about the foraging activities of flying-foxes in garden fruit trees [20]. Fear of disease transmission has also been noted to be of considerable concern to communities [21] as flying-foxes are reservoirs for some potentially fatal viruses, including Australian Bat Lyssavirus and Hendra virus [22,23].

A significant challenge for land managers is that stakeholders involved in human-flying-fox conflict are likely to have competing views about when and how flying-foxes are managed. While negative stereotypes of bats as being evil and disease-ridden can be perpetuated by the media and influence public attitudes [24–27], many members of the public have positive attitudes towards flying-foxes [21,28]. Managers therefore need to consider the social, cultural and political forces that exist within communities, and to understand the factors that influence and motivate human attitudes [29].

Legislation can restrict possible management actions related to flying-foxes and their camps which can present another challenge. All four species of flying-fox in Australia are protected as native animals, with the Grey-headed and Spectacled flying-foxes also listed as 'Vulnerable' under the Australian Federal Environment Protection and Biodiversity Conservation (EPBC) Act 1999, and as Vulnerable or Rare in some States. Managers therefore need to reconcile the conservation objectives for these species with the rights and needs of the people that share their environment. Effective conflict management and conservation is further complicated by the highly mobile nature of flying-foxes. Three of the four species occur in three or more Australian States or territories (Figure 1) and are considered as single populations across their ranges [10,30]. However, management occurs primarily at the local scale as local government agencies (councils) are generally responsible for management.

A range of actions may be taken to mitigate conflict, and these can be broadly classified as community-focused or camp-based approaches. Community education and engagement is an example of a community-focused approach that aims to reduce conflict by changing perceptions and increasing tolerance towards flying-foxes. Camp-based approaches focus on the flying-foxes or the vegetation they roost in. For example, vegetation along the borders of camps may be removed or modified to create 'buffers' that aim to lessen the noise and smell associated with flying-fox camps. Another approach is the dispersal of flying-foxes from roost sites using direct or indirect methods [31]. Direct dispersal uses various forms of disturbance such as smoke, lights and noise to deter flying-foxes from roosting

after they return from foraging. Indirect dispersal involves the removal or modification of the roost site vegetation when the flying-foxes are absent from the site.

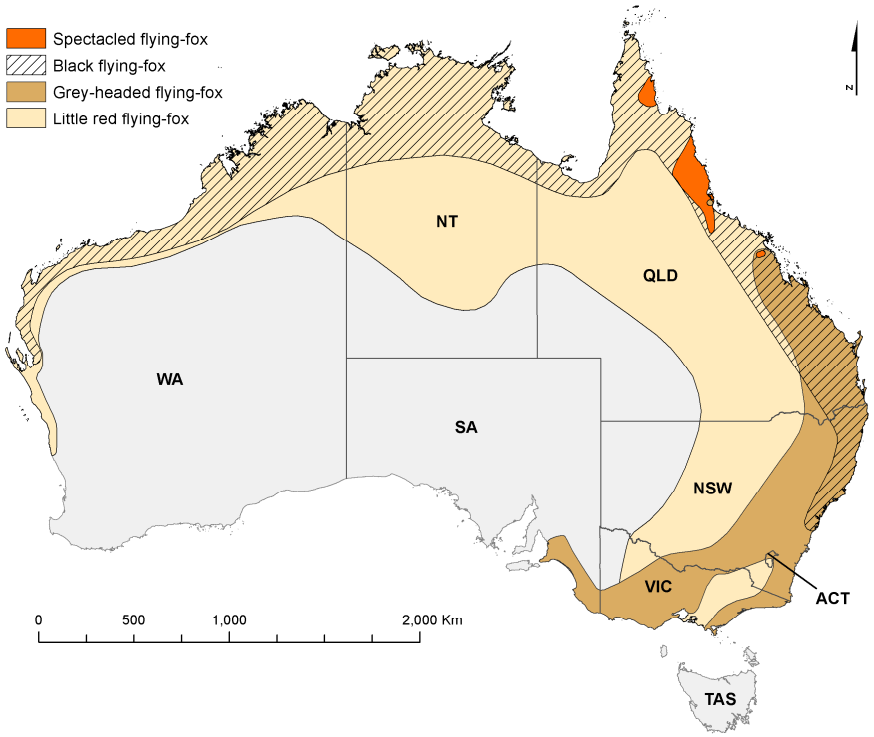

Figure 1. Distribution of Australia's four mainland flying-fox species.

The prevalence and success (or otherwise) of management actions has been largely undocumented, and flying-fox management remains a contentious and challenging issue. This study aimed to synthesise the knowledge and perspectives of managers of urban flying-fox camps to determine: (i) the perceived impacts of flying-foxes on surrounding communities; (ii) the factors that trigger management actions; (iii) the strategies that are being used to mitigate human-flying fox conflict and, (iv) the cost and perceived effectiveness of management actions. It is hoped that this will help land managers make informed decisions and lead to better outcomes for both communities and flying-foxes.

2. Materials and Methods

2.1. Study Area and Target Population

This study targeted land managers from the eastern states of Australia (Queensland, New South Wales, Victoria and South Australia), as this is where most of the overlap in the range of flying-foxes and urban areas occur, and it is primarily camps in these states that are sites of conflict. On-ground managers within local government agencies who were actively involved in the assessment and management of camps were targeted for surveying.

Human ethics approval to conduct this study was obtained from the University of Melbourne Faculty of Science Human Ethics Advisory Group, approval number (Ethics ID) 1647100.1.

2.2. Semi-Structured Interviews

2.2.1. Survey Design

Semi-structured interviews are a widely used tool in qualitative research because they allow the interviewer to delve deeply into the subject matter [32]. The aim of the semi-structured interviews was to develop a better understanding of the language that is used by land managers, and to

identify the full range of considerations relevant to flying-fox management for the development of an online questionnaire. A set of open-ended questions provided a structure for the interview; however, the format was conversational to allow participants to provide as much or as little information as they wanted, and in their own words. All participants were experienced flying-fox managers and were familiar with the topic being discussed. Interviews were conducted until such time as a saturation point had been reached where additional interviews were generating little new information. Interview length ranged from 32 to 71 min, the average being 51 min, and all interviews were conducted by one researcher (KC).

The main topics explored in the semi-structured interviews were:

- Whether the management agency had a management plan and/or objectives for flying-fox management.
- Description of camps within the jurisdiction of the management agency—e.g., how many camps there were, and how many were being actively managed.
- How nearby communities were being affected by the camps.
- What the history of management was—what strategies had been considered or implemented, and were there were any constraints around implementation of certain strategies.
- How the community and flying-foxes had responded to management actions.

2.2.2. Participant Selection and Recruitment

Most participants were recruited during a National Flying-Fox Forum held on 6 & 7 September 2016 in Brisbane, Australia. Over 70 people attended from a range of management agencies, primarily from Queensland, but also from New South Wales and Victoria. A Plain Language Statement was distributed to all land managers who verbally expressed an interest in participating (n = 15) or subsequently via email or phone (n = 3). Partner organisations (local and state government agencies) associated with a wider project looking at human-flying fox conflict were also approached to seek participants (n = 6). A final set of 15 participants was then purposively selected to represent a broad geographic range of experiences and variation across relevant demographic variables (e.g., population density). Eight participants were from Queensland, five from New South Wales, and two from Victoria. Twelve of these 15 participants were from local government agencies (councils), one was from an environmental consultancy, one from a State government department and one from a peak industry body. Interviews were conducted from September to November 2016. One interview was conducted face-to-face; the remainder were conducted via telephone.

2.2.3. Data Analysis

Analysis of the transcribed interviews was conducted using thematic content analysis whereby the texts, words, and/or phrases were coded to identify patterns and common themes [33]. Analysis was undertaken using Nvivo 11.4.0 and used an inductive approach, which entailed a thorough exploration of raw data to identify the concepts or themes through interpretation by the researcher [34].

2.3. Online Questionnaire

2.3.1. Questionnaire Design

The aim of the questionnaire was to collect both qualitative and quantitative data from a larger sample of managers. Interview data were used to inform the design of the questionnaire and questions explored the range of themes covered in the interviews. The questionnaire was delivered using the Survey Monkey™ platform and consisted of 35 questions that required a mix of short answers, open-ended text responses, dichotomous responses (Yes/No), and Likert scale (1–7) responses (File S1), and were non-randomised to ensure that there was a logical flow. Participants were asked to provide

responses in relation to only one camp, but were given the opportunity to provide responses to more than one camp if they wished. The questionnaire included questions on:

- Location and description of the nominated flying-fox camp (i.e., number of bats, proximity to community)
- What the managers perceived the impacts of flying foxes on local communities to be.
- What factors influenced any decision to undertake active management.
- What management actions had been used in the past five years, how effective they perceived them to be, and what the financial cost of management was.

2.3.2. Participant Selection and Recruitment

A link to the questionnaire was contained in a request for participation letter, which was distributed via email to potential respondents through the Local Government Association of Queensland (LGAQ), and the Threatened Species Principal Project Officer for the NSW Office of Environment and Heritage (OEH). In Victoria the Department of Environment, Land, Water & Planning provided information on the location of some camps, and the interactive flying-fox web viewer that presents data collected via the National Flying-fox Monitoring Programme was also used to identify camps (http://www.environment.gov.au/webgis-framework/apps/ffc-wide/ffc-wide.jsf, accessed 6 October 2016). At the time of the study there was only one known urban flying-fox camp in South Australia (Adelaide). The questionnaire link was also sent to members of the Australasian Bat Society, and a notice was put in the Local Government NSW Natural Resources Management online bulletin (Issue 102, November 2016).

2.4. Data Analysis

The medians and quartiles of questions using the Likert scale or numeric responses were calculated. Summary statistics (e.g., number of occurrences, percentages) were calculated for other quantitative data. Text data were analysed for major themes.

3. Results

We received 54 responses to the online questionnaire; 24 from Queensland (from 17 different agencies), 25 from New South Wales (from 21 different agencies), four from Victoria (all from different agencies), and one from South Australia. All respondents provided information on at least one camp, and four respondents provided information on two or more camps. Two respondents from different agencies provided information on four camps, and three respondents from different agencies provided information on another camp. The sample of land managers and flying-fox camps included in the study is not necessarily representative, and reported rates of management actions used and levels of effectiveness should not be generalised to all managers and camps. All four species of flying-fox used the camps in our data set (sometimes forming mixed camps) and there was no clear relationship between species composition and the responses managers provided in the surveys, so data from all camps are presented together here.

3.1. Impacts and Triggers

The main impacts of flying-fox camps on surrounding communities were perceived by managers to be noise, smell, concerns about disease transmission, and the loss of amenity (Figure 2a). Beliefs that communities were concerned the presence of the camp could have a negative influence on property values and business profits were also relatively high. Potential impacts on the local environment (e.g., water contamination) were considered to be relatively unimportant. Other factors included mess from faeces, concern that camps would continue to grow, the inability to hold a commemorative celebration in a park, and impacts on tourism.

Residents were identified as the most important trigger for making the decision to actively manage a camp (Figure 2b). Vocal stakeholders, media coverage and elected representatives were also relatively important and interview data supported the questionnaire results. For example, one manager stated that, "*You can't really get a good idea of what everyone wants because the vocal minority just drowned everyone out.*" (Interview #12). Another stated that, "*This community was a really difficult one because we had a very vocal councillor who was feeding quite a lot of misinformation into the local area.*" (Interview #8). Other factors considered to be important triggers were: the flying-fox camp expanding onto Council land (which relates to jurisdiction of management), the public risk from trees (presumably as a result of damage resulting from roosting flying-foxes), and the relative costs and potential benefit of actions.

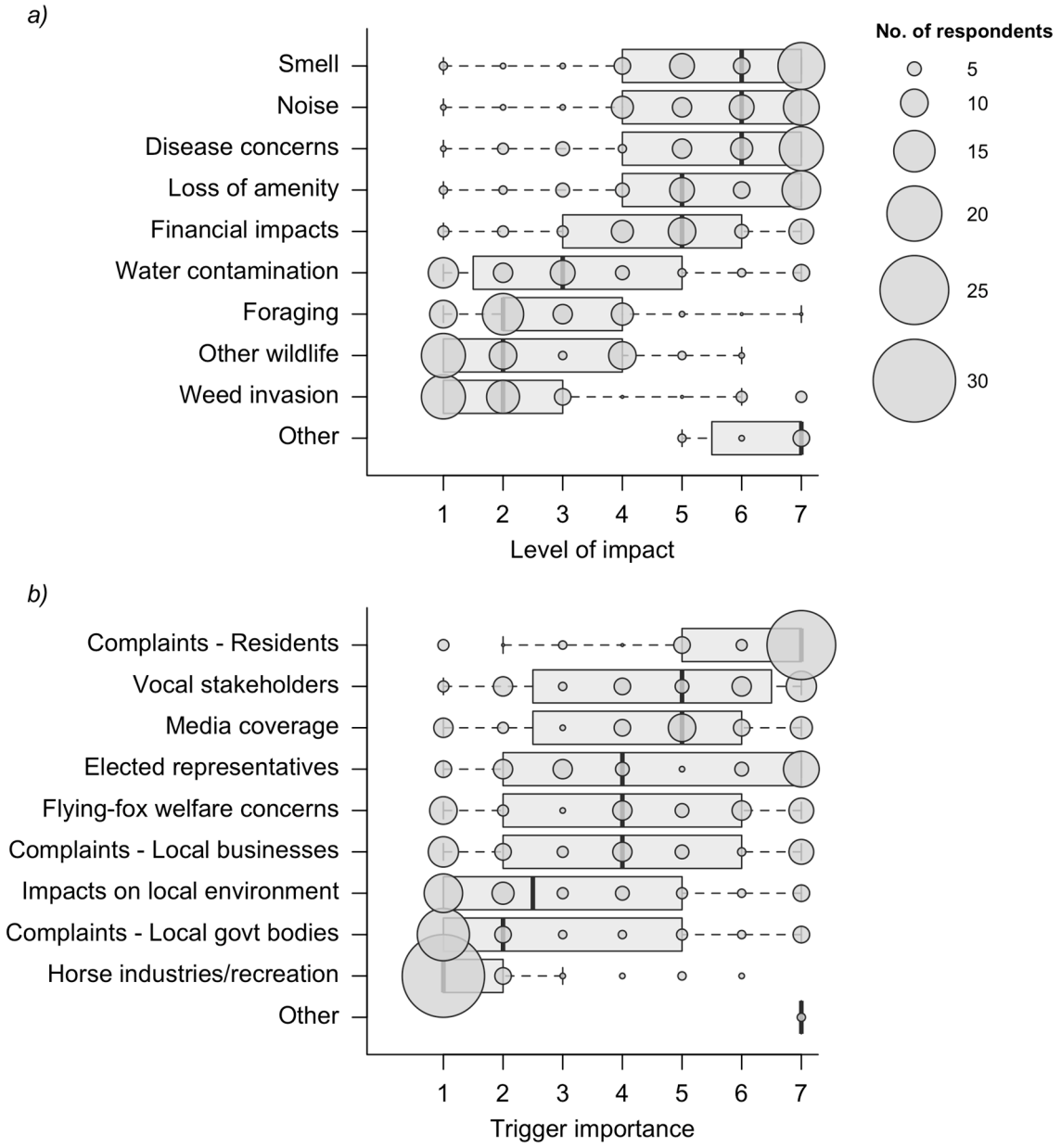

Figure 2. (**a**) Perceived degree of impact that the flying-fox camp was having on the local community and environment. Level of impact ranges from 1 = no impact, 4 = moderate impact, and 7 = serious impact. (**b**) The importance of a range of factors in triggering a decision to actively manage the flying-fox camp. Trigger importance ranges from 1 = not important, 4 = moderately important, and 7 = very important.

3.2. Management Actions

The most common management activity undertaken by land managers was stakeholder education and awareness, which occurred at 84% of actively managed camps. Camp-based management actions had also been implemented at the majority (75%) of camps. No respondents indicated that they had culled bats, or used artificial roosting habitat or noise attenuation fencing (Figure 3). Management actions nominated under 'Other' were: Relocation of impacted residents for four months (comprising of one resident, a church service and a kindergarten), installation of barrier fencing, removal of orphaned or dead flying-foxes from park and playground as soon as possible, and daily cleaning of pathways and playground equipment. Eleven camps were not being actively managed because they were not within the jurisdiction of the respondent or there was little community concern. More than one type of management action had been implemented at the majority (72%) of camps.

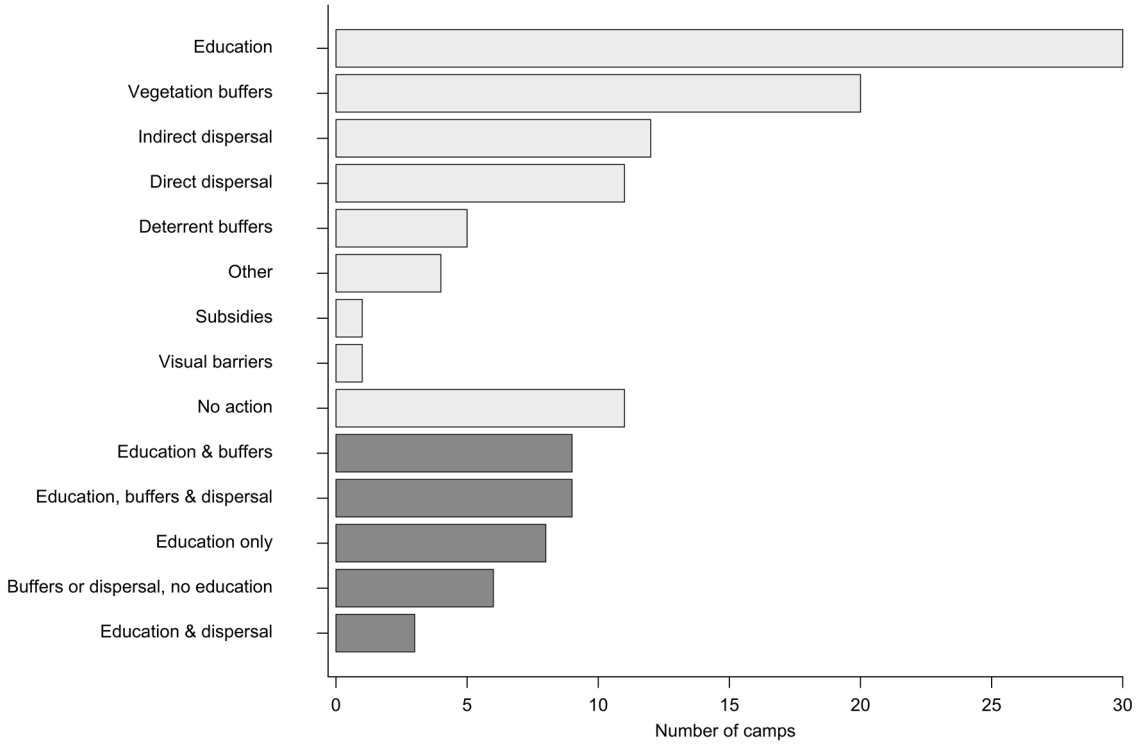

Figure 3. Frequency of management actions implemented at flying-fox camps in the last five years. Light grey bars indicate where that action was undertaken at any camp, while dark grey bars show specifically where that action was used in isolation (e.g., "Education only") or combination (e.g., "Education and dispersal"). For these darker bars 'buffers' includes vegetation removal and deterrents, and 'dispersal' includes direct and indirect methods. A description of each management technique is provided (File S2).

3.3. Effectiveness

Effectiveness was measured against four factors for camp-based actions and against three factors for community focused actions, plus an 'overall' rating for all actions.

3.3.1. Community-Focused Actions

Community education and awareness was perceived to be the least effective action in reducing complaints and improving amenity, and most managers did not consider this action effective in increasing tolerance towards flying-foxes (Figure 4). Interview responses suggested it often appeared to be done reactively or was not well implemented, as it was variously described as being done

'on demand', 'ad hoc', or 'being done poorly'. The extent and type of stakeholder engagement varied considerably with some respondents indicating the only activities undertaken were responding to individual complaints, press releases, signage at the camp or letter-drops, whilst others implemented a wider range of activities such as 'bat nights' and community meetings. Some managers expressed that effective education and awareness can be difficult because of unrealistic expectations about management actions, or because people were resistant to changing their views. For example, "*The community expectation is for the flying-foxes to go away and never return which is unrealistic, however education and awareness efforts have not been successful in changing community expectations or understanding*" (Questionnaire #28), and " *they're not interested in being educated and they don't care what we do as long as we get rid of them.*" (Interview #6). In some instances, managers found direct engagement with individuals was effective; "*Engaging directly was very effective as residents were pleased to know that something was actually being done (despite limitations on possible management actions) and to have a personal connection with land managers*" (Survey #37).

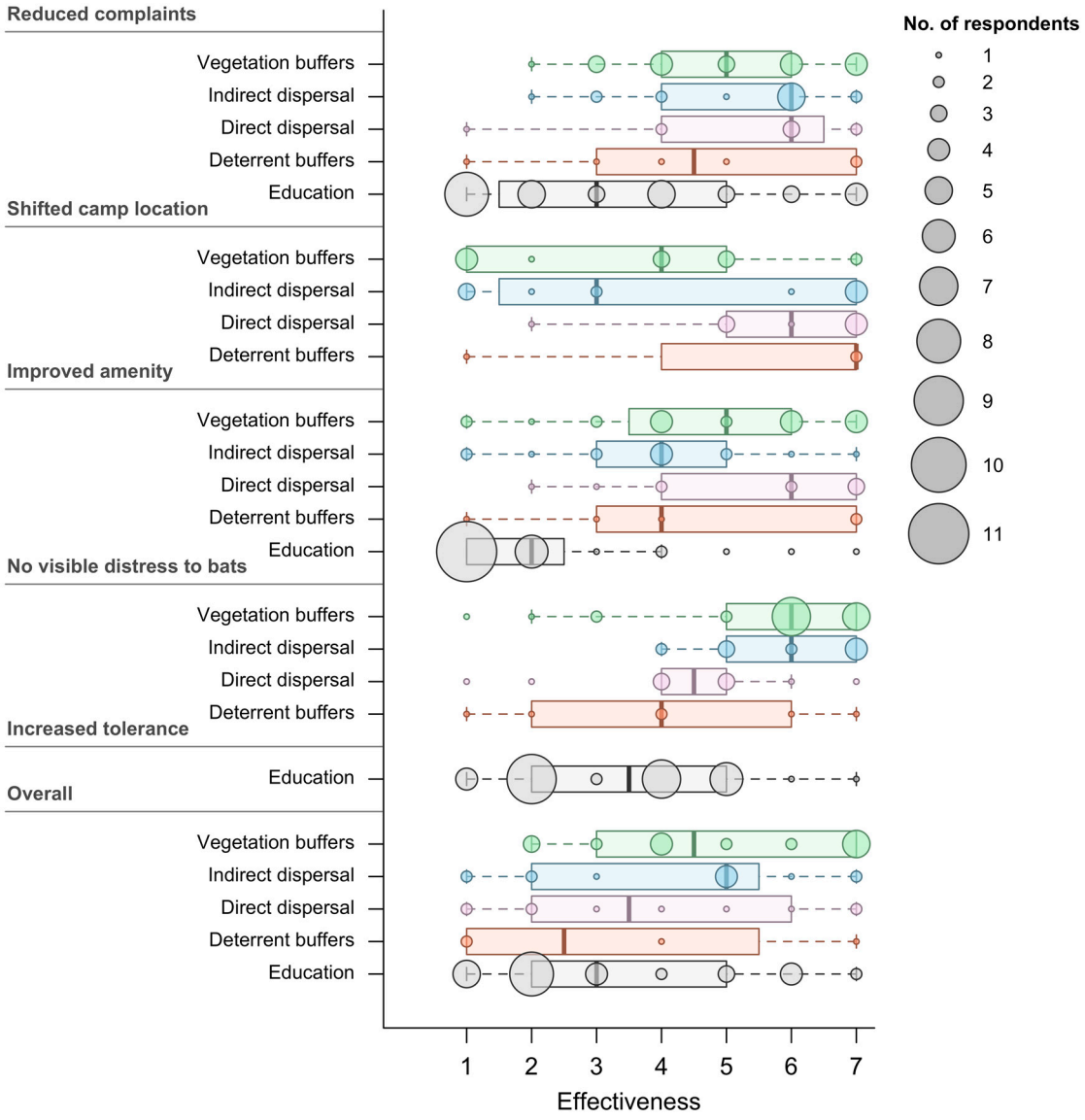

Figure 4. Perceived effectiveness of the five most commonly used management actions across a range of factors. Level of effectiveness ranges from 1 = not effective, 4 = moderately effective, and 7 = very effective.

3.3.2. Camp-Based Management Actions

The second most frequently used action to address human-flying fox conflict was the creation of buffers via vegetation removal or modification, and managers considered this approach to be quite effective in reducing complaints, improving amenity and had minimal impact on the flying-foxes; "*The creation of a buffer was the best possible action for this urban roost that met the requirements of the local residents and ensured welfare of the flying-foxes*" (Questionnaire #23). However, some residents were perceived to value the vegetation more highly; "*Many residents liked the bats and did not want to lose the vegetation*" (Questionnaire #35). Buffers may be less effective during times of high abundance of flying-foxes; "*Most of the time (buffers) are helpful, but when we get big numbers then I don't think they can really help that . . . it'll help to some degree but it won't resolve all issues*" (Interview #6). The creation of buffers reduces the area of roost habitat and this can cause spillovers into new areas when flying-fox numbers increase; "*Our action essentially means that the camp expands into areas previously not used by flying-foxes.*" (Questionnaire #38).

The use of deterrents to create a buffer was rare and most respondents did not provide any detail on the deterrents used. In one instance low levels of smoke and noise were used, and in another, sprinklers were used to deter flying-foxes from roosting in certain trees. The manager considered sprinklers to be highly effective because it did not necessarily require the removal of vegetation, and it gave impacted residents a sense of control because they determined when and how often the sprinklers are used. As a result, the residents seemed more tolerant of the flying-foxes; "*Because I've given control of the sprinklers to the residents, the residents have chosen to keep the sprinklers off even though the bats are there*" (Interview #12).

Indirect dispersal, where vegetation is removed from a roost site in the absence of bats to achieve a permanent deterrent to roosting, was perceived to cause little stress to flying-foxes, and to be quite effective in reducing complaints. It was considered less effective in improving amenity and also considered less effective overall. Community opposition to vegetation removal is a potential negative consequence of this mitigation action; "*Unless you're removing almost all of the vegetation in a flying-fox camp, your dispersal is not going to work and often the community doesn't want to remove the vegetation because they actually like it.*" (Interview #13). Potentially there was some ambiguity as to the definition of indirect dispersal (also commonly called 'passive dispersal') regarding the extent of vegetation removal. All roost vegetation may be cleared in some instances, whereas at other sites only sections of it is cleared or modified, and this may influence effectiveness of this approach.

Land managers who used direct dispersal (disturbance methods to deter flying-foxes from roosting at a particular site) considered it to be effective at reducing complaints, improving amenity and shifting the location of the camp (Figure 4). It provided relief for residents from sensory and disease concerns without impacting the local vegetation, but there was considerable variability in managers' perceptions of the degree of distress direct dispersal causes flying-foxes. However, overall success was only perceived to be moderate. Of the 12 respondents who had used this management technique, 83% indicated the flying-foxes had returned to the site, and 64% indicated they had or were considering undertaking further dispersal actions.

3.4. Cost of Management Strategies

Not all participants provided information on management costs, and there was considerable variation in costs for most actions. Although stakeholder engagement was the most common management strategy, comparatively very little money was spent on this approach (Figure 5). With the exception of one respondent whose agency spent approximately AU$40,000, the majority of respondents indicated they had spent less than AU$5000. Time frames of expenditure (where specified) ranged from days up to 5 years.

Costs for the creation of buffers via vegetation ranged from less than AU$10,000 up to AU$80,000, and from AU$5000 up to AU$56,000 for indirect dispersal. Costs for direct dispersal showed the greatest variation ranging from approximately AU$10,000 for a dispersal done over five days,

through to AU$320,000 for a dispersal campaign that ran for 16 months and required five people for two hours a day, five days a week, up to a AU$2M multi-year campaign.

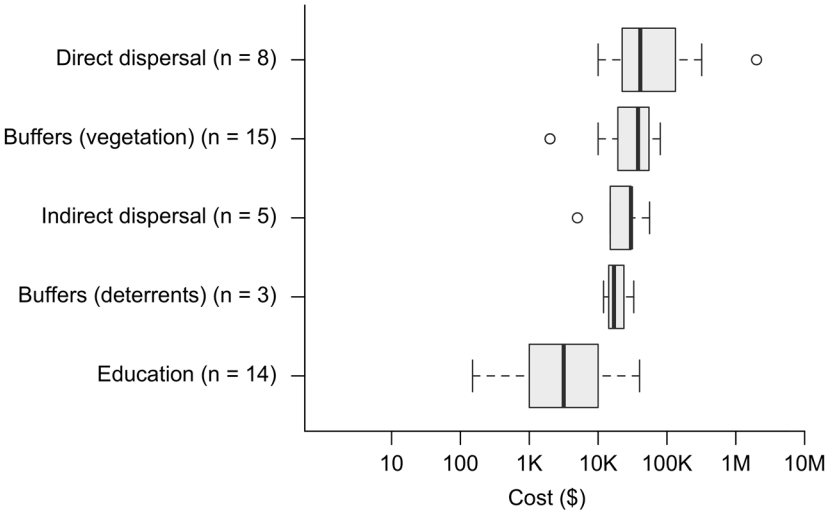

Figure 5. Box plots showing the quantiles and outliers for the comparative cost of management actions. Note that the *x*-axis is shown on the log scale to ensure all data are visible and ranges from $10 to $10,000,000.

4. Discussion

Human-wildlife conflict resulting from the presence of flying-fox camps in urban areas is a high-profile and contentious issue across many cities and towns in eastern Australia. The primary aim of this study was to survey land managers to better understand how and why different management actions had been implemented, and gain some insights as to their perceived effectiveness. The results show there is no 'one size fits all' management action that will be effective in all situations. All management actions were perceived to be highly effective at some locations, but were considered ineffective at others, and it was evident that the human dimensions of conflict strongly influence all aspects of flying-fox management.

4.1. Factors Influencing Decision-Making

The term 'human dimensions' refers to the recognition that stakeholders have a range of values, attitudes and beliefs about wildlife and wildlife management [35,36]. Managers were very aware that there was a wide range of views about flying-foxes and their associated impacts within their communities. For example, in one instance there was a "*neighbourhood war basically between two neighbours, one who loved the bats and one who hated them*" (Interview #8). This is consistent with other research on the perceptions of bats [20,21] which found they were "very different things to different people" [37]. Instances such as these highlight the presence of differing values for wildlife, which makes decision-making about the appropriate response very challenging.

An important finding was that in many instances vocal stakeholders were influencing the decision to undertake active management, therefore land managers might be hearing from only a subset of the community. Many expressed that the most vocal stakeholders were those who viewed the flying-foxes as a problem that needed to be dealt with, and some of these people were not directly impacted by the presence of the flying-foxes; e.g., "*Some people are genuinely impacted by the flying foxes, then there's others that tend not to be so impacted but they're more vocal*" (Interview #6).

Elected representatives were also perceived to be an important factor in triggering the decision to undertake management, as they may not only be influencing community perceptions of the flying-foxes but could also influence community expectations regarding the management approach—e.g., "*Council*

had received a number of complaints and then one of the councillors put a notice in motion up to say let's get rid of the bats" (Interview #9). The media and management approaches undertaken by nearby councils can also create expectations within communities that something can and should be done; "*You are working against whatever the media's put in, or whatever an adjacent council has done, the expectation is that you would do the same thing here.*" (Interview #7).

4.2. Management Effectiveness

4.2.1. Community Engagement/Education

Stakeholder education and awareness programs were used by most land managers, but the majority of respondents perceived these efforts to be of only moderate to low effectiveness for reducing conflict. This approach can take a wide range of forms and this could influence effectiveness, but the results suggest that in many instances this approach is not being prioritised, as the majority of agencies had spent less than AU$5000. This does not necessarily equate to effort spent, as land managers are potentially spending a proportion of their time on community engagement and have not reflected this in cost estimates. The other consideration is that community education may often be undertaken by environmental management staff that may not have the relevant skills or training in community engagement, particularly in small councils. Therefore, a potential pathway to improved effectiveness of this approach is the use of adequately trained personnel.

There was some evidence from this study that education can be effective in reducing concerns about disease transmission, but it cannot directly mitigate the impacts of noise, smell and mess associated with flying-fox camps. Some managers found attempts to educate residents regarding management options and the ecological value of the flying-foxes were not effective in changing strongly held views, though some studies suggest education can increase willingness, or capacity, to tolerate wildlife [3,38,39].

The effectiveness of community engagement and education activities is also subject to the vagaries of flying-fox movements. At one location an ongoing community engagement program had been implemented in areas that were frequently used by flying-foxes, and the land manager considered this quite effective in encouraging co-existence. However, an unusually large influx of flying-foxes resulted in much higher numbers, plus the establishment of camps in new areas that had not been the subject of any community engagement programs, and the conflict was significant. This experience highlights that it may be difficult for agencies to keep pace with the dynamic and unpredictable nature of camp occupancy.

4.2.2. Camp-Based Management Approaches

The creation of buffers via vegetation removal or modification aims to encourage co-existence by addressing the sensory and disease risk concerns of residents without inflicting significant disturbance on the flying-foxes, and land managers considered this approach to be quite effective in achieving these aims. Buffers provide a relatively long-term solution to the problem as the modified vegetation may remain unappealing as a roosting site for a number of years, and in some instances the creation of buffers only required the removal of weed species. However, some residents may value the vegetation and find this approach unacceptable. From the responses provided it was unclear whether the width of the buffers adequately mitigated the impacts of noise and smell; the majority of buffers were described as being between 10 m to 50 m wide, but people can be adversely affected by strong odour from a camp located up to 200 m away [28].

The majority of land managers who used direct dispersal considered it effective at reducing complaints, improving amenity and shifting the location of the camp. This approach provides relief for residents from sensory and disease concerns, and does this without impacting on the local vegetation. However, this approach can be expensive, and in over 80% of the cases described in this study, the relief that dispersal provided from impacts was only short-term because flying-foxes returned

to the site. This is consistent with the literature; Roberts and Eby (2013) reviewed the outcomes of 17 camp dispersals that took place in Queensland between 1990–2013 and determined they were all unsuccessful in the long term because the dispersed flying-foxes did not abandon the local area, and conflict was still present in 71% of cases [40].

The range of cost estimates suggests that the intensity of disturbance events vary significantly so this may potentially be influencing the effectiveness of this approach. There have been a small number of successful direct dispersals, such as the dispersal of Grey-headed flying-foxes from the Melbourne Royal Botanic Gardens (RBG) in 2003. This dispersal was very well resourced (it is reported to have cost over $3 million), and achieved the aim of relocating the flying-foxes to a better location [41]. However, a 'splinter' camp also formed in an unexpected location during the dispersal, which has since become permanently occupied (van der Ree, unpub data). This camp has caused little community conflict to date, but splinter camps may become new sites of conflict and the risk of this happening was a concern expressed by many managers. One documented example of splintering that caused conflict occurred in Maclean, New South Wales [42].

This study has primarily focused on the response of the community as perceived by camp managers, but the ecological impacts of management on flying-foxes should also be considered. Although only relatively small areas of each roost site are modified by the creation of buffers, cumulatively they add to the problem of decreasing suitable roost habitat, which has been identified as a significant concern for the recovery of Grey-headed flying-foxes [43]. Survey respondents who had undertaken buffers were asked for the area of vegetation cleared, and in total approximately 180,000 m^2 of roost habitat had been modified. Due to the high rates of among-camp movements, flying-foxes within a region may experience multiple dispersals and the potential long-term impacts of this are unknown [13].

4.3. Human-Human Conflict

It was apparent that conflict between the managing agency and the community can also be considerable. Land managers used phrases such as 'vitriolic' and 'abusive' to describe the response of some community members towards them, and they often felt considerable pressure from stakeholder groups with different objectives; "*We do have several organisations and individuals locally who are pro the bats and think we're seriously doing the wrong thing removing vegetation or doing anything in that space, so we have pressure from both sides*" (Interview #10). Therefore, the implementation of a management action designed to alleviate conflict, can of itself become a source of further conflict.

Conflict of this type is particularly frequent in instances where the species is protected by legislation [44]. The protected status of Grey-headed and Spectacled flying-foxes means there are restrictions around management options and this may not align with the views of certain individuals or groups who may resent the non-utilitarian views enforced by government agencies. For example, "*Some definitely want them outta there and it's all council's fault*" (Interview #6). Trust and credibility can also diminish, and community frustration increase, if the managing agency is seen to be spending substantial resources on ineffective conflict mitigation measures [45,46]. On the other hand, the implementation of a management action can be evidence that residents' concerns have been heard, and that the land managers were prepared to try and assist them. For example: "*The community could see some action and some understanding and some sort of ownership of the issue from council.*" (Interview #1).

5. Conclusions

It is important to acknowledge that whilst we focused on conflict, not all interactions between humans and flying-foxes are negative. However, where conflict does occur, mitigation remains a significant challenge for land managers.

This study provides further evidence that noise, smell and fear of disease are major causes of concern to residents, and that a limited range of camp-based management approaches such as buffers and dispersals are frequently being used to attempt to mitigate these impacts. Whilst these actions

are perceived to be effective in certain circumstances, there is now widespread acceptance in the human-wildlife conflict literature that management actions that focus purely on wildlife, as opposed to the human community also, will be of limited effectiveness. We also found this to be the case for flying-foxes, in that the identification and incorporation of all relevant stakeholder perspectives into the decision-making process will be critical for effective management. To date, flying-fox managers have had little quantitative evidence at their disposal with which to make informed decisions and we hope that the data presented here will usefully inform future decisions on management of urban flying-fox camps.

Supplementary Materials: The following are available online at http://www.mdpi.com/1424-2818/10/2/39/s1, File S1. Online questionnaire; File S2. Description of management actions; File S3. Numeric data (csv).

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References

1. Woodroffe, R.; Thirgood, S.; Rabinowitz, A. The impact of human-wildlife conflict on natural systems. *Conserv. Biol. Ser.* **2005**, *9*, 1. [CrossRef]
2. Nyhus, P.J. Human-wildlife conflict and coexistence. *Annu. Rev. Environ. Resour.* **2016**, *41*, 143–171. [CrossRef]
3. Messmer, T.A. Human–wildlife conflicts: Emerging challenges and opportunities. *Hum.-Wildl. Confl.* **2009**, *3*, 10–17.
4. Dickman, A.J. Complexities of conflict: The importance of considering social factors for effectively resolving human–wildlife conflict. *Anim. Conserv.* **2010**, *13*, 458–466. [CrossRef]
5. Marshall, A.G. Bats, flowers and fruit: Evolutionary relationships in the Old World. *Biol. J. Linn. Soc.* **1983**, *20*, 115–135. [CrossRef]
6. Ghanem, S.J.; Voigt, C.C. Increasing Awareness of Ecosystem Services Provided by Bats. *Adv. Study Behav.* **2012**, *44*, 279–302. [CrossRef]
7. Fujita, M.S.; Tuttle, M.D. Flying Foxes (Chiroptera: Pteropodidae): Threatened Animals of Key Ecological and Economic Importance. *Conserv. Biol.* **1991**, *5*, 455–463. [CrossRef]
8. Aziz, S.A.; Olival, K.J.; Bumrungsri, S.; Richards, G.C.; Racey, P.A. The conflict between pteropodid bats and fruit growers: Species, legislation and mitigation. In *Bats in the Anthropocene: Conservation of Bats in a Changing World*; Springer: Berlin, Germany, 2016; pp. 377–426.
9. Eby, P. Seasonal movements of grey-headed flying-foxes, *Pteropus poliocephalus* (Chiroptera: Pteropodidae), from two maternity camps in northern New South Wales. *Wildl. Res.* **1991**, *18*, 547–559. [CrossRef]
10. Roberts, B.J.; Catterall, C.P.; Eby, P.; Kanowski, J. Long-distance and frequent movements of the flying-fox *Pteropus poliocephalus*: Implications for management. *PLoS ONE* **2012**, *7*, e42532. [CrossRef] [PubMed]
11. Nelson, J. Movements of Australian flying foxes (Pteropodidae: Megachiroptera). *Aust. J. Zool.* **1965**, *13*, 53–74. [CrossRef]
12. Nelson, J.E. Behaviour of Australian pteropodidae (Megacheroptera). *Anim. Behav.* **1965**, *13*, 544–557. [CrossRef]
13. Hall, L.S. Management of flying-fox camps: What have we learnt in the last twenty five years. In *Managing the Grey-Headed Flying-Fox as a Threatened Species in New South Wales*; Royal Zoological Society of New South Wales: Sydney, Australia, 2002.

14. Richards, G.C. The development of strategies for management of the flying-fox colony at the Royal Botanic Gardens, Sydney. In *Managing the Grey-Headed Flying-Fox as a Threatened Species in New South Wales*; Royal Zoological Society of New South Wales: Sydney, Australia, 2002; pp. 196–201.
15. Van Der Ree, R.; McDonnell, M.J.; Temby, I.; Nelson, J.; Whittingham, E. The establishment and dynamics of a recently established urban camp of flying foxes (*Pteropus poliocephalus*) outside their geographic range. *J. Zool.* **2006**, *268*, 177–185. [CrossRef]
16. Parris, K.M.; Hazell, D.L. Biotic effects of climate change in urban environments: The case of the grey-headed flying-fox (*Pteropus poliocephalus*) in Melbourne, Australia. *Biol. Conserv.* **2005**, *124*, 267–276. [CrossRef]
17. Eby, P.; Richards, G.; Collins, L.; Parry-Jones, K. The distribution, abundance and vulnerability to population reduction of a nomadic nectarivore, the grey-headed flying-fox *Pteropus poliocephalus* in New South Wales, during a period of resource concentration. *Aust. Zool.* **1999**, *31*, 240–253. [CrossRef]
18. Williams, N.S.G.; Mcdonnell, M.J.; Phelan, G.K.; Keim, L.D.; Van Der Ree, R. Range expansion due to urbanization: Increased food resources attract Grey-headed Flying-foxes (*Pteropus poliocephalus*) to Melbourne. *Austral Ecol.* **2006**, *31*, 190–198. [CrossRef]
19. Parry-Jones, K.A.; Augee, M.L. Factors affecting the occupation of a colony site in Sydney, New South Wales by the Grey-headed Flying-fox *Pteropus poliocephalus* (Pteropodidae). *Austral Ecol.* **2001**, *26*, 47–55.
20. Lunney, D.; Reid, A.; Matthews, A. Community perceptions of flying-foxes in New South Wales. In *Managing the Grey-Headed Flying-Fox as a Threatened Species in New South Wales*; Royal Zoological Society of New South Wales: Sydney, Australia, 2002; pp. 160–175.
21. Kung, N.Y.; Field, H.E.; McLaughlin, A.; Edson, D.; Taylor, M. Flying-foxes in the Australian urban environment—Community attitudes and opinions. *One Health* **2015**, *1*, 24–30. [CrossRef] [PubMed]
22. Hooper, P.T.; Lunt, R.A.; Gould, A.R.; Samaratunga, H.; Hyatt, A.D.; Gleeson, L.J.; Rodwell, B.J.; Rupprecht, C.E.; Smith, J.S.; Murray, P.K. A new lyssavirus—The first endemic rabies-related virus recognized in Australia. *Bull. Inst. Pasteur* **1997**, *95*, 209–218. [CrossRef]
23. Halpin, K.; Hyatt, A.D.; Fogarty, R.; Middleton, D.; Bingham, J.; Epstein, J.H.; Rahman, S.A.; Hughes, T.; Smith, C.; Field, H.E.; et al. Pteropid bats are confirmed as the reservoir hosts of henipaviruses: A comprehensive experimental study of virus transmission. *Am. J. Trop. Med. Hyg.* **2011**, *85*, 946–951. [CrossRef] [PubMed]
24. Prokop, P.; Fančovičová, J.; Kubiatko, M. Vampires are still alive: Slovakian students' attitudes toward bats. *Anthrozoos* **2009**, *22*, 19–30. [CrossRef]
25. Thiriet, D. Flying fox conservation laws, policies and practices in Australia: A case study in conserving unpopular species. *Australas. J. Nat. Resour. Law Policy* **2010**, *13*, 161–194.
26. Ballard, G. Understanding People to Improve Wildlife Management: Case Studies in Human Dimensions Research from NSW, Australia. Ph.D. Thesis, University of New England, Armidale, Australia, 2005.
27. Knight, A.J. "Bats, snakes and spiders, Oh my!" How aesthetic and negativistic attitudes, and other concepts predict support for species protection. *J. Environ. Psychol.* **2008**, *28*, 94–103. [CrossRef]
28. Eby, P.; Lunney, D. *Managing the Grey-Headed Flying-Fox as a Threatened Species in NSW*; Royal Zoological Society of New South Wales: Sydney, Australia, 2002.
29. St. John, F.A.V.; Edwards-Jones, G.; Jones, J.P.G. Conservation and human behaviour: Lessons from social psychology. *Wildl. Res.* **2011**, *37*, 658–667. [CrossRef]
30. Webb, N.J.; Tidemann, C.R. Mobility of Australian flying-foxes, *Pteropus* spp. (Megachiroptera): Evidence from genetic variation. *Proc. Biol. Sci.* **1996**, *263*, 497–502. [CrossRef] [PubMed]
31. Office of Environment and Heritage. *Flying-Fox Camp Management Policy 2015*; Office of Environment and Heritage: Sydney South, Austrlia, 2015.
32. Bryman, A. *Social Research Methods*; Oxford University Press: Oxford, UK, 2015.
33. Green, J.; Thorogood, N. *Qualitative Methods for Health Research*; Sage: Thousand Oaks, CA, USA, 2013.
34. Thomas, D.R. A general inductive approach for analyzing qualitative evaluation data. *Am. J. Eval.* **2006**, *27*, 237–246. [CrossRef]
35. Decker, D.J.; Chase, L.C. Human dimensions of living with wildlife: A management challenge for the 21st century. *Wildl. Soc. Bull.* **1997**, *25*, 788–795.
36. Enck, J.W.; Decker, D.J. Examining assumptions in wildlife management: A contribution of human dimensions inquiry. *Hum. Dimens. Wildl.* **1997**, *2*, 56–72. [CrossRef]

37. Tidemann, C.R. Sustainable management of the Grey-headed Flying-fox *Pteropus poliocephalus*. In *Managing the Grey-Headed Flying-Fox as a Threatened Species in New South Wales*; Royal Zoological Society of New South Wales: Sydney, Australia, 2002; pp. 122–127.
38. Sillero-Zubiri, C.; Sukumar, R.; Treves, A. Living with wildlife: The roots of conflict and the solutions. In *Key Topics in Conservation Biology*; Blackwell Pub. Ltd.: Malden, MA, USA, 2007; pp. 266–272.
39. Marker, L.L.; Mills, M.G.L.; Macdonald, D.W. Factors influencing perceptions of conflict and tolerance toward cheetahs on Namibian farmlands. *Conserv. Biol.* **2003**, *17*, 1290–1298. [CrossRef]
40. Roberts, B.; Eby, P. Review of past flying-fox dispersal actions between 1990–2013. Unpublished report. 2013.
41. Perry, D. " Endemic Aliens": Grey-Headed Flying-Foxes at the Melbourne Royal Botanic Gardens. *J. Anim. Ethics* **2012**, *2*, 162–178. [CrossRef]
42. Roberts, B.J.; Eby, P.; Catterall, C.P.; Kanowski, J.; Bennett, G. The outcomes and costs of relocating flying-fox camps: Insights from the case of Maclean, Australia. In *The Biology and Conservation of Australasian Bats*; Royal Zoological Society of New South Wales: Mosman, Australia, 2011; pp. 277–287.
43. Commonwealth of Australia. *Draft Recovery Plan for the Grey-Headed Flying-Fox Pteropus poliocephalus*; Commonwealth of Australia: Canberra, Australia, 2017; pp. 1–37.
44. Treves, A.; Wallace, R.B.; Naughton-Treves, L.; Morales, A. Co-managing human–wildlife conflicts: A review. *Hum. Dimens. Wildl.* **2006**, *11*, 383–396. [CrossRef]
45. Baruch-Mordo, S.; Breck, S.W.; Wilson, K.R.; Broderick, J. The carrot or the stick? evaluation of education and enforcement as management tools for human-wildlife conflicts. *PLoS ONE* **2011**, *6*, e15681. [CrossRef] [PubMed]
46. Temby, I.D. Urban wildlife issues in Australia. In Proceedings of the 4th International Symposium on Wildlife Conservation, Tucson, AZ, USA, 1–5 May 1999; The University of Arizona: Tucson, AZ, USA, 2004; pp. 26–34.